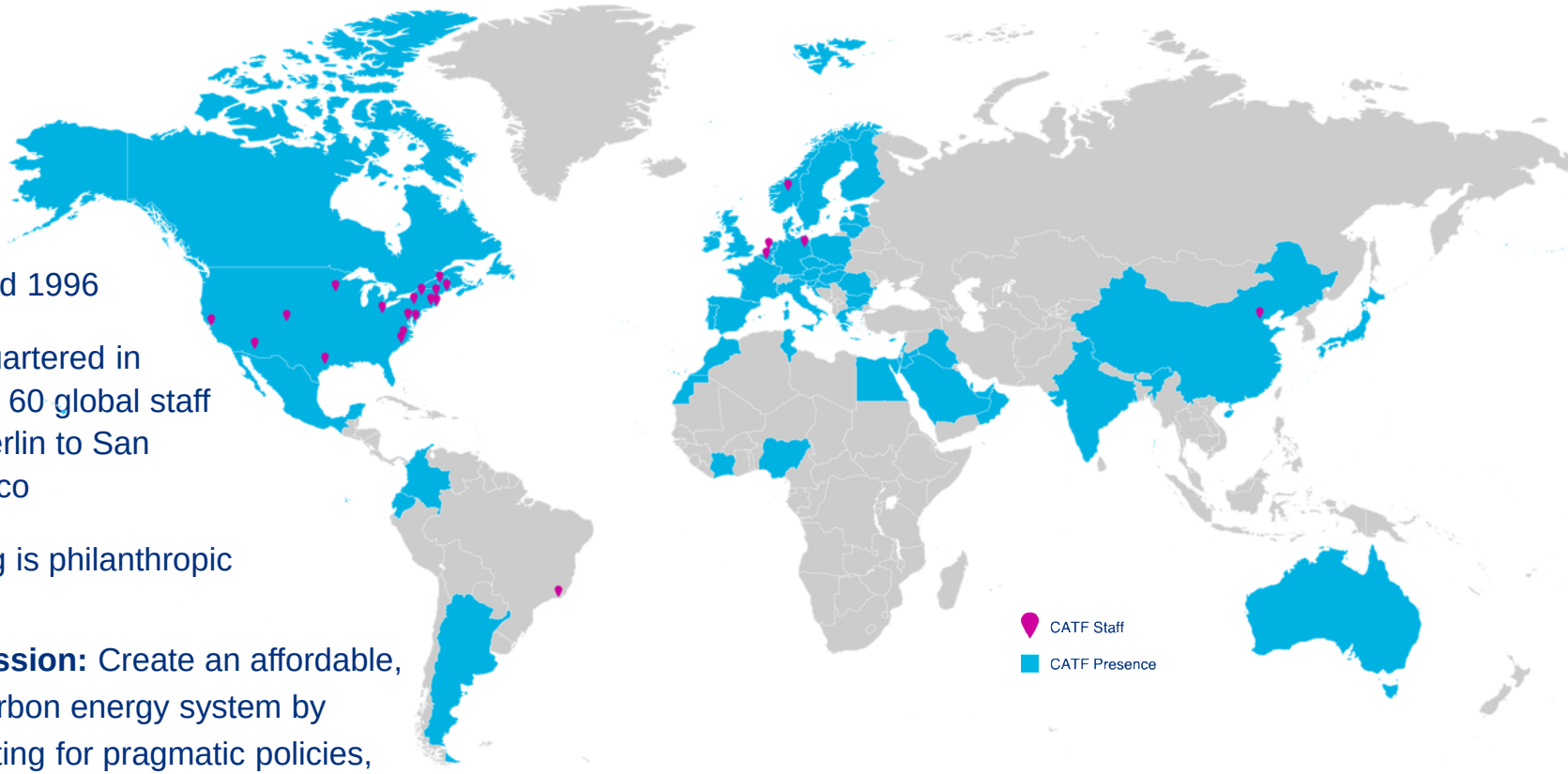
CLEAN AIR TASK FORCE

Overview the process of capture, transport, and storage

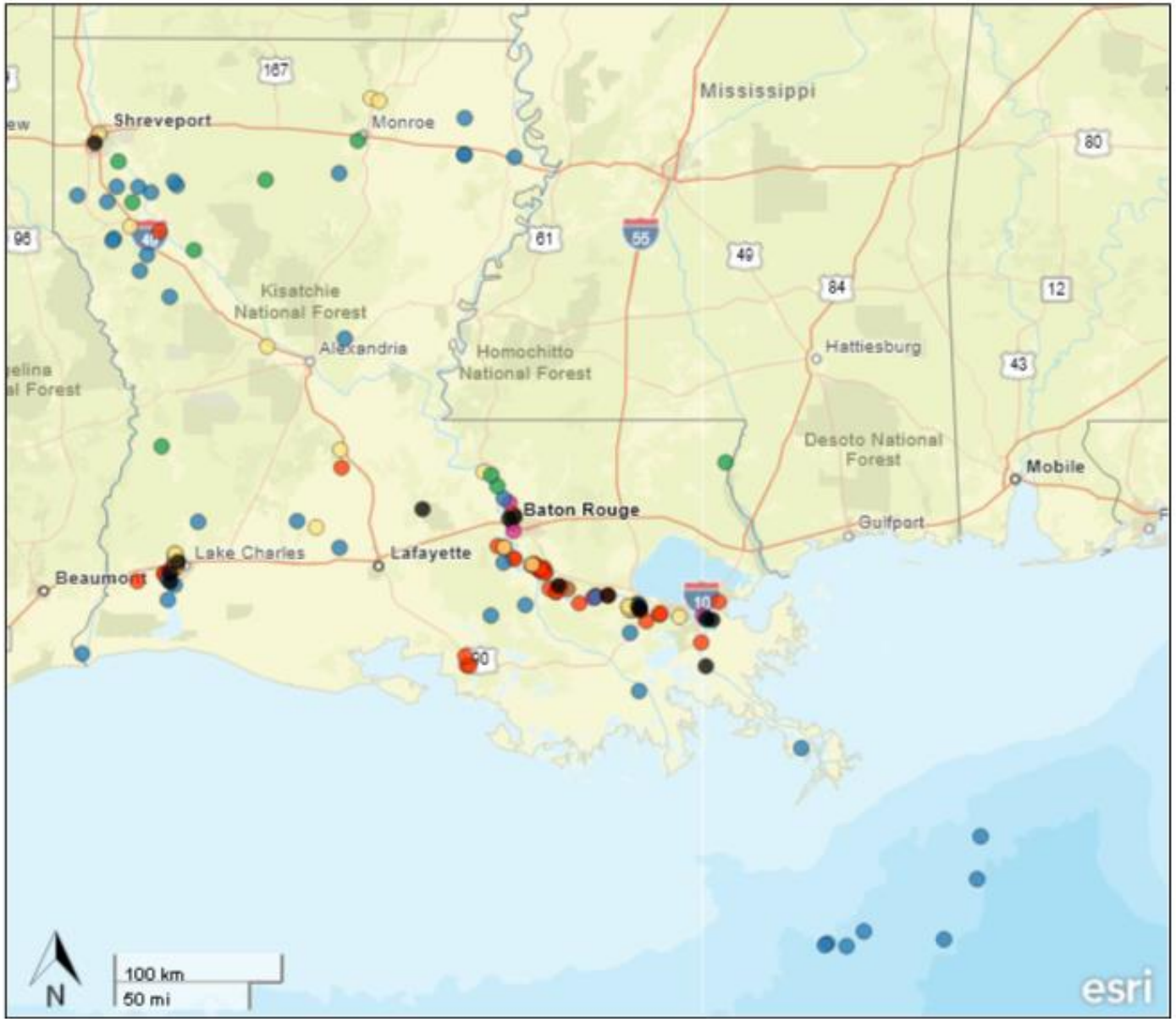
October 2021

About the Clean Air Task Force



- Founded 1996
- Headquartered in Boston, 60 global staff from Berlin to San Francisco
- Funding is philanthropic
- **Our Mission:** Create an affordable, zero carbon energy system by advocating for pragmatic policies, new business strategies, and advanced technologies.
- **Our Vision**: Meet the world's rising energy demand in a way that is financially, socially, and environmentally sustainable.

Louisiana Power and Industrial CO2 Sources



Capture Performance

CO_2 Removal

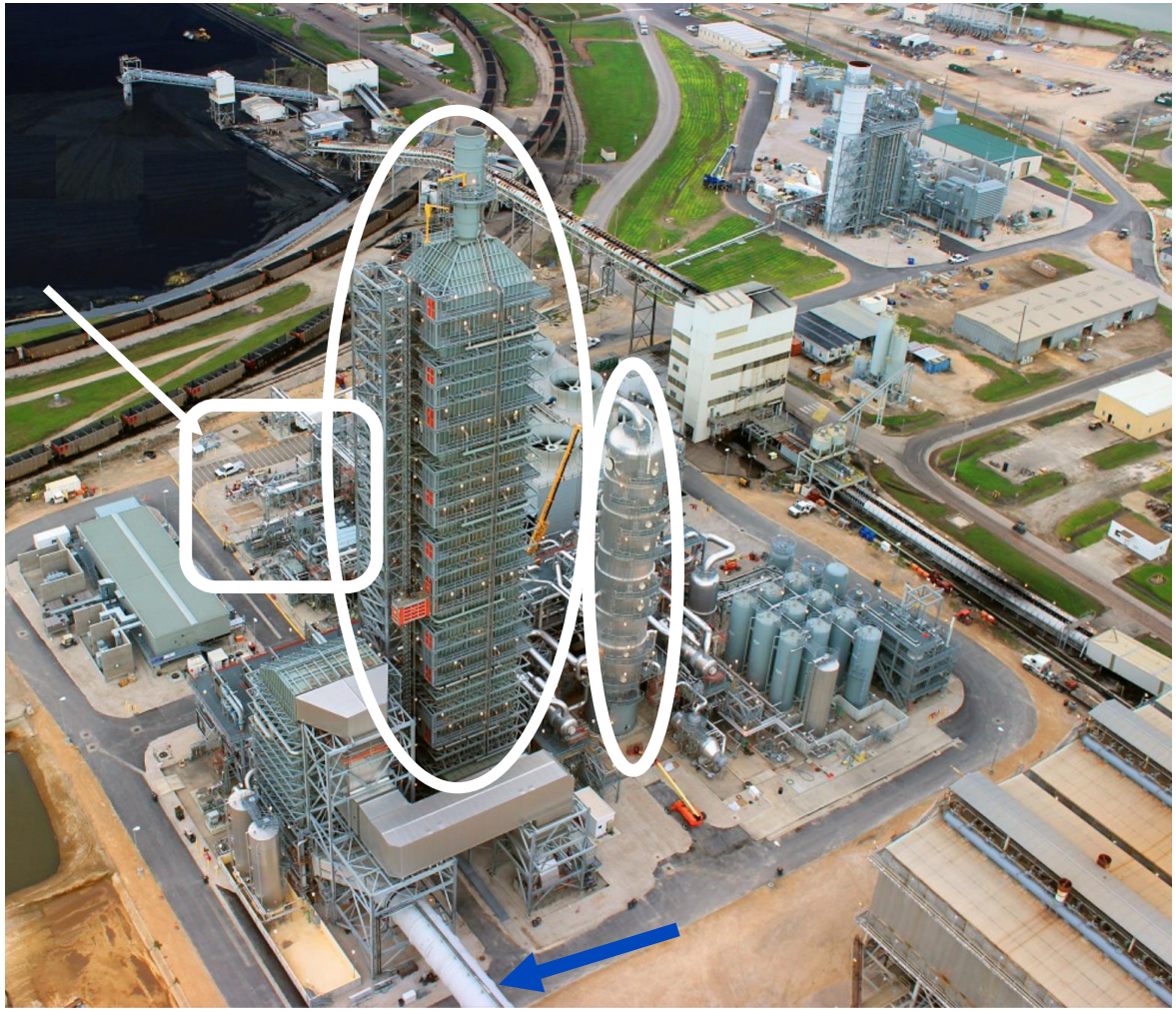
- Capture systems have been designed for 90% removal in the past.
- International Energy Agency (IEA) sees 90% as an “artificial limit” with no technical reason why 98% or 99% emission reductions possible.[1]
- 95% capture is common today in many plans, including the $4.5 billion Air Products hydrogen plant announced in Louisiana last week.

Co-benefits with Criteria Pollutants

- Most carbon capture systems for industrial and power sources rely on amines to remove the CO2.
- Amines must be protected from other pollutants commonly found in emissions.
- Amine-based carbon capture systems are designed to remove virtually all of the following:
  - SO2
  - Particulate matter
  - NO2
  - SO3
  - Many metals

1. IEAGHG, “Towards Zero Emissions CCS from Power Stations using Higher Capture Rates or Biomass”, 2019/02, March, 2019.

How Capture Works



Interesting Studies

MITSUBISHI HEAVY INDUSTRIES

NEWS CAREERS

ABOUT US OUR EXPERTISE PRODUCTS SUSTAINABILITY INVI

HOME - NEWS - MITSUBISHI HEAVY INDUSTRIES ENGINEERING SUCCESSFULLY COMPLETESTESTING OF NEW "KS-21TM" S

PRESS INFORMATION

Mitsubishi Heavy Industries Engineering Successfully Completes

Testing of New "KS-21™" Solvent for CO_2 Capture

2021-10-19

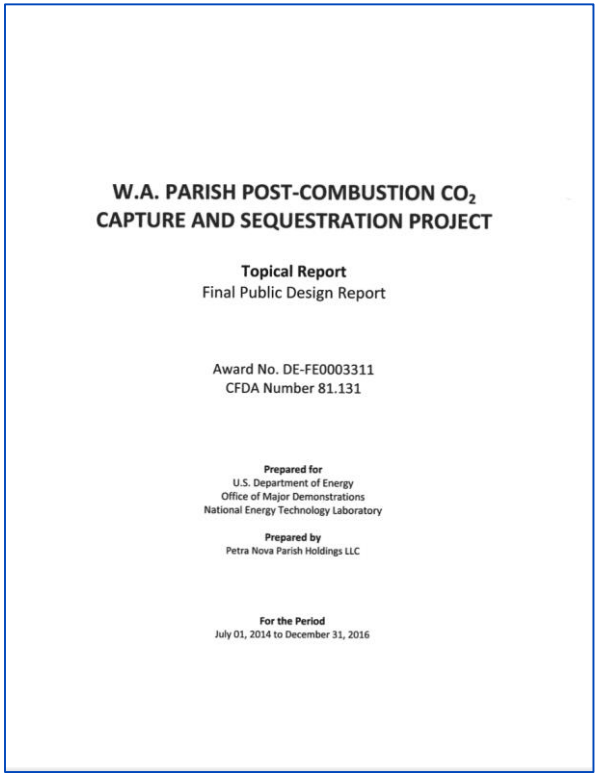
- KS-21™ solvent, jointly developed with KEPCO, achieves up to 99.8% flue-gas carbon capture rate
- Data on KS-21™'s technological advantages will enable full commercialization and drive growth

Tokyo, October 19, 2021 – Mitsubishi Heavy Industries Engineering, Ltd. (MHIENG), a Group company of Mitsubishi Heavy Industries, Ltd. (MHI) based in Yokohama, has concluded testing of its new proprietary solvent for capturing CO_2 at the Technology Centre Mongstad (TCM) (Note1) in Norway, one of the world's largest carbon capture demonstration facilities that is recognized for its state-of-the-art equipment and specialized expertise. These outstanding test results complete MHIENG's commercialization of KS-21™, a new amine-based solvent used in the "Advanced KM CDR Process™(Note2)" developed by MHIENG in collaboration with The Kansai Electric Power Co., Inc. (KEPCO), and paves the way for the future expansion of MHIENG's carbon capture, utilization and storage (CCUS) business.

The testing was carried out between early May and late August 2021 in Norway, one of the world's most advanced nations in the field of carbon capture. The KS-21™'s performance was tested to confirm a carbon capture rate of 95-98%, which is above the current industry standard (approx. 90%), from flue gas emitted by a gas turbine at TCM's test facility. The results indicate outstanding energy-

Describes 95-98% capture results from Mongstad Test Center, with highest rate achieving 99.8%

Link



W.A. PARISH POST-COMBUSTION CO_2 CAPTURE AND SEQUESTRATION PROJECT

Topical Report
Final Public Design Report

Award No. DE-FE0003311
CFDA Number 81.131

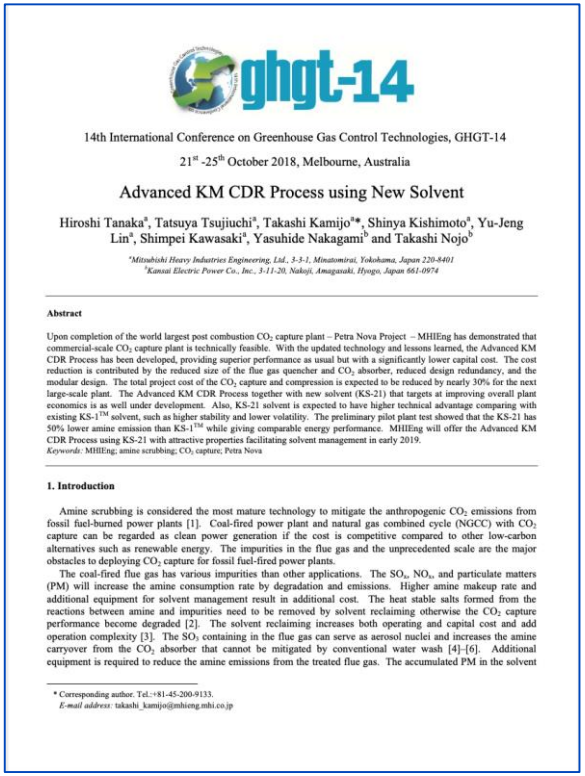
Prepared for
U.S. Department of Energy
Office of Major Demonstrations
National Energy Technology Laboratory

Prepared by
Petra Nova Parish Holdings LLC

For the Period
July 01, 2014 to December 31, 2016

Describes equipment costs and operating parameters

Report Link



ghgt-14

14th International Conference on Greenhouse Gas Control Technologies, GHGT-14

21st -25th October 2018, Melbourne, Australia

Advanced KM CDR Process using New Solvent

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Abstract

Upon completion of the world largest post combustion CO_2 capture plant – Petra Nova Project – MHIEng has demonstrated that commercial-scale CO_2 capture plant is technically feasible. With the updated technology and lessons learned, the Advanced KM CDR Process has been developed, providing superior performance as usual but with a significantly lower capital cost. The cost reduction is contributed by the reduced size of the flue gas quencher and CO_2 absorber, reduced design redundancy, and the modular design. The total project cost of the CO_2 capture and compression is expected to be reduced by nearly 30% for the next large-scale plant. The Advanced KM CDR Process together with new solvent (KS-21) that targets at improving overall plant economics is as well under development. Also, KS-21 solvent is expected to have higher technical advantage comparing with existing KS-1™ solvent, such as higher stability and lower volatility. The preliminary pilot plant test showed that the KS-21 has 50% lower amine emission than KS-1™ while giving comparable energy performance. MHIEng will offer the Advanced KM CDR Process using KS-21 with attractive properties facilitating solvent management in early 2019.

Keywords: MHIEng; amine scrubbing; CO_2 capture; Petra Nova

1. Introduction

Amine scrubbing is considered the most mature technology to mitigate the anthropogenic CO_2 emissions from fossil fuel-burned power plants [1]. Coal-fired power plant and natural gas combined cycle (NGCC) with CO_2 capture can be regarded as clean power generation if the cost is competitive compared to other low-carbon alternatives such as renewable energy. The impurities in the flue gas and the unprecedented scale are the major obstacles to deploying CO_2 capture for fossil fuel-fired power plants.

The coal-fired flue gas has various impurities than other applications. The SO_x, NO_x, and particulate matters (PM) will increase the amine consumption rate by degradation and emissions. Higher amine makeup rate and additional equipment for solvent management result in additional cost. The heat stable salts formed from the reactions between amine and impurities need to be removed by solvent reclaiming otherwise the CO_2 capture performance become degraded [2]. The solvent reclaiming increases both operating and capital cost and add operation complexity [3]. The SO_3 containing in the flue gas can serve as aerosol nuclei and increases the amine carryover from the CO_2 absorber that cannot be mitigated by conventional water wash [4]–[6]. Additional equipment is required to reduce the amine emissions from the treated flue gas. The accumulated PM in the solvent

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Describes 30% cost reduction on next plant after Petra Nova

Report Link

National Costs of Capture and Storage Costs

Industry	Capture ($/tonne) [1]	Transport & Storage ($/tonne)[2]	Total CCS ($/tonne)
Ethanol	12-30	25	37-55
Ammonia	15-21	25	40-46
Gas Processing	11-16	25	36-41
Cement	40-75	25	65-100
Refineries	43-68	25	68-93
Steel	55-64	25	80-89
Petrochemicals	57-60	25	82-85
Hydrogen	36-57	25	61-82
Gas Plant	54-63	25	79-88
Coal Plant	46-60	25	71-85

Notes:
1. Transport Infrastructure for Carbon Capture and Storage, Great Plains Institute and Wyoming University, 2020.
2. CATF national estimate used in this analysis. Low could be $3/tonne to $40/tonne.

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